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NATURAL BRIDGE, VIRGINIA.

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THE

NATIONAL GEOGRAPHIC MAGAZINE

THE NATURAL BRIDGE OF VIRGINIA

BY

CHARLES D. WALCOTT

The Natural Bridge of Virginia is one of those striking geographic features of America which, like Niagara falls and many other natural features, will in time disappear under the action of the agencies of erosion. The same forces that created, will ultimately destroy them. In the case of Niagara, the rate of wear of the platform over which the water rushes has been measured, and the rate of retreat of the falls of the stream is known. Natural bridge is slowly but surely wearing away; and it appears to be desirable to record by photographs and notes the present condition of the bridge as a means of determining in the future the changes that occur from time to time. For this purpose a set of photographs, with notes taken in 1891, have been placed in the library of the United States Geological Survey.

The present article includes a few observations on the origin and the present condition of the bridge. The accompanying view (forming plate 21) is one looking northward through the arch, and it accurately represents the condition of the bridge and canyon at the time it was taken. It may be that a more detailed description, with a full series of views, will be published in the future.

During the field season of 1891 I studied the rocks exposed along the channel of Cedar creek, a small tributary of the James river in Rockbridge county, Virginia. The first strata

met with in passing up from the river are highly inclined limestones and shales of middle or upper Cambrian age. These are succeeded by the massive Knox dolomites, which are nearly vertical or inclined slightly westward. A few hundred feet below Natural bridge the westward dip decreases very rapidly, and at the bridge the beds are nearly horizontal, while a short distance above they are rising westward and dipping eastward toward the bridge at an angle of 5° to 10°. This increases to 20° to 25° higher up the stream.

A diagramatic section of the rocks cut through in the canyon of Cedar creek gives the outline shown in figure 1. The bridge is at *A*, Lace falls at *B*, and James river at *C*. No attempt is made to show the depth of the canyon or gorge through which Cedar creek flows.

It is not supposed that the present Cedar creek began to wear its channel across the edges of the upturned beds from *B* to *C* when the present topographic features were established; on the contrary, it began its work long before, under conditions

FIGURE 1.—*Attitude of Strata at Natural Bridge.*

and in rocks that have since disappeared in the general erosion of the surrounding country. The course of the stream was determined by circumstances connected with the life history of James river. When the latter obtained a new lease of active life and lowered its channel through the Blue ridge, Cedar creek began to cut down its bed in the peneplain and to prepare the way for the possibility of the existence of an arch over its channel.

The general mode of formation has long been described for this and other natural rock bridges. In this case in detail it is considered to be as follows: Cedar creek was engaged for a considerable period in excavating the gorge from the James river to a point not far below the present site of the bridge, where a fall appears to have existed, the summit of which was not far if at all below the present level of the top of the bridge. About this time the water found a subterranean passage in the limestone further up the stream than the present site of the bridge, and through this it flowed and discharged beneath the brink of the falls.

The passage gradually enlarged until all the waters of the creek passed through it and the bridge began its existence. What the length of this subterranean passage was is a matter of conjecture; it may have been one hundred or several hundred feet. All of its roof has disappeared except the narrow span of the bridge, and the abutting walls have been worn back by erosion until the gorge or canyon is much wider than at the bridge. The bridge is massive and strong, and the supporting walls rise in solid, almost unbroken, mural faces to the spring of the arch, nearly 200 feet above the bed of Cedar creek, as clearly shown in the accompanying plate (which is reproduced mechanically from a photograph taken by the author).

The position of the massive layers of limestone at the center of the low synclinal gives them power to resist erosion to a much greater extent than the upturned strata above and below the bridge. The condition of the latter favors rapid disintegration, and the result is shown in the widening of the gorge. The retreating lower level of the stream is now at Lace falls, nearly a mile above the bridge. The gorge below the bridge widens out more rapidly, owing partly to the erosion caused by a small brook that enters from the north, partly to the greater period of erosion to which it has been subjected.

On the northern side, opposite Pulpit rock, about twenty feet west of the public road, the summit of the bridge is 236 feet above the water, and this part of the arch has a thickness of 44 feet and a span of from 45 to 60 feet. The western edge is about ten feet higher, and the eastern edge about ten feet lower than the central point.

The massive layers of limestone forming the bridge are gradually wearing away on the outer edges from the action of water and frost. If water-breaks were arranged so that the water could not flow in upon the bridge and about it from the southwestern side, and if a shed with water-tight roof were built over the arch, disintegration and destruction would be indefinitely postponed. As it is, it will be many centuries before the natural processes of erosion now at work upon and within the arch will completely break it down.

Since the preceding was written, an article has appeared in the *New York Tribune* of May 15, 1893, in which an account is given of the discovery of a passage in the limestones near Natural

bridge that extends from the plain above down to the stream below. It is described as follows:

"The passage was probably created by a stream of water finding a crevice in the limestone mountain, and by the gnawing of gases, the same causes that created the natural bridge. But it has all the appearance of design and purpose. A brief description by one who has recently seen it in the light of hundreds of candles shows at the entrance a room about twenty feet by ten, with a ceiling sixty feet in height, then a low, arched doorway into a room narrower than the former and extending forty or fifty feet up a steep flight of steps. The arches here are from fifteen to twenty feet in height, and their color a liquid blue. There are a few stalactities from the ceiling and many crystal forms on the wall. Turning here from a direct course through another arched doorway, beautifully decorated, about six feet in height, there is a round room, twenty feet in diameter and perhaps fifty feet from pit to dome. Out of the side of this springs a stone cascade, perfect as any waterfall, transparent at the lower edge, about ten feet in length and eight in breadth. As the light is thrown upon this it has all the appearance of a living waterfall. A passage under this, over a bridge, leads to a labyrinth barely wide enough for one to pass. The arch is about fifteen feet in height and the walls glisten like polished marble. These windings extend about thirty feet and open into a well-shaped room not at any point more fifteen feet in diameter and opening, about thirty feet above, to the sky."

From the description it is evident that the passage was worn by percolating waters that found their way from the plain above to the baselevel cut by the stream below, along some previously existing crevices. This process of erosion may be seen at the "Underground river" between Natural bridge and Lace falls, where a strong current of water flows through a channel in the limestone that is about ten feet above the level of Cedar creek and only exposed to view for a few feet of its length. All of the phenomena observed at Natural bridge and in the canyon of Cedar creek are repeated in many limestone regions. Sometimes they give rise to underground caverns, as at Mammoth cave, and more rarely to canyons and natural bridges. The illustration at the natural bridge is one of the finest known, and worthy of study by any one interested in geologic phenomena or the beautiful in nature.

THE GEOGRAPHICAL POSITION AND HEIGHT OF MOUNT SAINT ELIAS

BY

DR T. C. MENDENHALL

(*Presented before the Society April 28, 1893*)

In connection with the survey of the boundary line between Alaska and the British Northwest Territory it became necessary to determine the geographical position of mount Saint Elias.

Previous approximate determinations had shown that the peak of this mountain must be very near the 141st meridian, which constitutes the greater part of this boundary line, and that its distance from the seacoast must be very nearly ten marine leagues, which by treaty is to determine the position of the line in the absence of a range of mountains parallel to the windings of the coast.

It thus appeared that this peak is likely to prove of very great value as a corner-stone in this great boundary line, being at the junction of the 141st meridian and that part of the line which is so vaguely defined in the treaty.

The execution of the work in the immediate vicinity of the mountain was intrusted to assistants J. E. McGrath and J. Henry Turner, whose previous explorations and long residence in the interior of Alaska in connection with the determination of the 141st meridian are well known to the members of this Society.*

The complete reduction of the observations made has not yet been accomplished, but enough has been done to show the geographical position of the mountain peak within a very small error, and the Society will probably be interested in the preliminary results of this work, which are not likely to be modified sensibly by the completed calculations.

The fieldwork was executed during the summer of 1892.

*An account of their work appears in Nat. Geog. Mag., vol. iv, 1892, pp. 177–197.

The party was carried to the working ground by the Coast Survey Steamer *Hassler*, in command of Captain Harber, who personally took great interest in the work and facilitated its successful performance very much, taking a very important part, in fact, in the determination of the difference of longitude between Sitka and the astronomical station at Yakutat bay. In the absence of telegraphic connection with any of these points, a series of chronometric journeys was made between Tacoma, which is near one of the telegraph longitude stations of the great system of the United States Coast and Geodetic Survey, and Sitka, which has been fixed as the base of the longitude work throughout the territory of Alaska.

Contemporaneously a series of journeys was made between Sitka and the astronomical station at Yakutat bay by the Coast Survey Steamer *Hassler*, and by these two loops the longitude of the stations was connected with that of the telegraphic system of the United States. Time observations at Tacoma and the comparison of chronometers at that point were under the direction of assistant J. F. Pratt. Six complete chronometer tours from Tacoma to Sitka and return were made on board of the Steamer *Queen*, the chronometers being in charge of Mr. T. D. Davidson, of San Francisco; this link having also been taken in by the *Hassler* chronometers on her way to and from the field, seven complete journeys are available between Tacoma and Sitka. Six complete journeys between Sitka and the astronomical station at Yakutat bay were made. An astronomical station was established at Sitka under the direction of sub-assistant Fremont Morse, who had charge of time-observations and the comparison of both sets of chronometers on reaching that point. Seven chronometers made the journeys between Tacoma and Sitka, and the same number between Sitka and Yakutat bay. The astronomical station at the latter place was in charge of assistant J. Henry Turner. The connection of this station trigonometrically with the summit of mount Saint Elias was under the direction of assistant J. E. McGrath. The astronomical station was on the southern side of Yakutat bay, and the measured base line from which the triangulation was developed was on the northern side. The length of this line was a little less than 7,000 metres, or about four and a half miles. The scheme of triangulation is shown on the accompanying sketch (figure 2). The latitude of the astronomical station was determined by

vertical circle observations of the sun's limb by the method of circum-meridian altitudes and also by the use of a meridian telescope and the Talcott differential method. The vertical circle used was ten inches in diameter and read to five seconds by means of four verniers. The latitude here given depends on these observations, as those made by the meridian telescope have not yet been reduced.

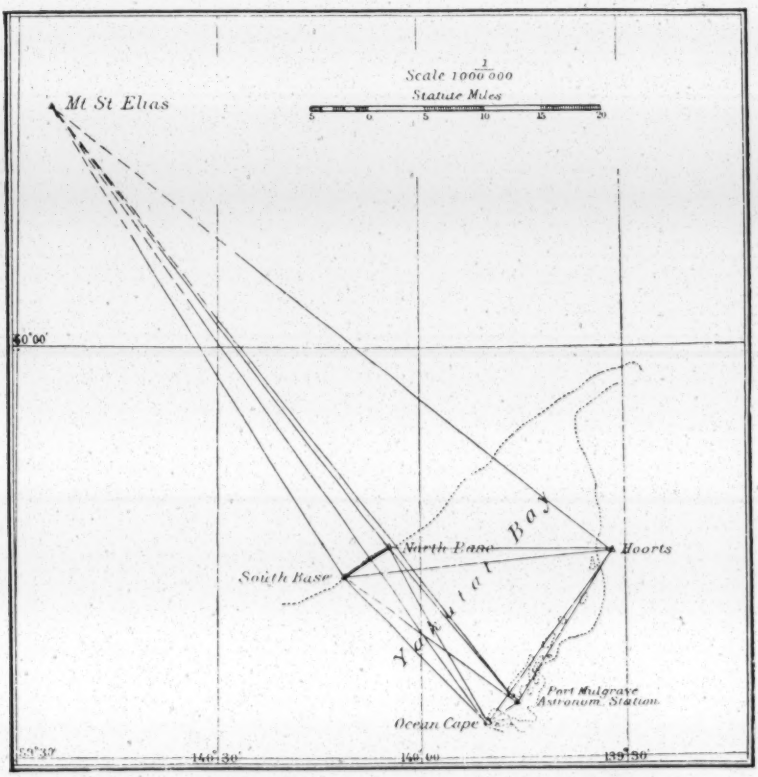


FIGURE 2.—*Triangulation in the vicinity of Mount Saint Elias.*

Of the six chronometric tours between Sitka and Yakutat bay three only have been reduced, and the results are as follows:

First trip, June 8 to 13; difference of longitude, 17 m. 48.17 sec.
Second trip, June 24 to 29; " " " 17 " 48.31 "
Third trip, July 9 to 14; " " " 17 " 48.16 "
Of which the indiscriminate mean is 17 m. 48.21 sec.

A preliminary reduction of a portion of the chronometric comparisons between Tacoma and Sitka gives for the longitude of Sitka 9 hours 1 minute 20.5 seconds, from which we have the adopted longitude of Yakutat astronomical station 9 hours 19 minutes 8.7 seconds. The latitude of this station from circum-meridian observations on the sun's limb, consisting of sixteen pointings on the sun near culmination on August 1, 1892, was 59° 33′ 51.8″, and on August 11, 1892, from twenty pointings, the result was 59° 33′ 48.2″, the mean of which is 59° 33′ 50″, which is accepted as the latitude of this station, subject, of course, to further small correction from the reduction of the results obtained from the meridian telescope work. Extending these coördinates to the summit of mount Saint Elias by means of the scheme of triangulation as shown in the sketch, the latitude of the summit is found to be 60° 17′ 35″, and the longitude 140° 55′ 21.5″.

The principal base for the determination of the position of the summit of the mountain was a line connecting mount Hoorts and South base. The length of this line was a little less than 38,000 metres, or about 23½ miles, and the angle which is subtended at mount Saint Elias was about 20°.

Incidentally in connection with this work, the height of the summit of the mountain was determined. A series of zenith distance measurements was executed from five stations, namely: North base, South base, mount Hoorts, Ocean cape, and the astronomical station. At the latter point observations were made on fourteen different days. The result for each day is the mean of three sets of six repetitions each, and the series is as follows, the observations being made near noon:

ZENITH DISTANCE OF MOUNT SAINT ELIAS.

June	11, 1892	87° 20′ 50.3″
"	18, "	87° 20′ 64.2″
"	27, "	87° 20′ 51.8″
"	28, "	87° 20′ 51.3″
July	9, "	87° 20′ 57.1″
"	10, "	87° 20′ 49.8″
"	11, "	87° 20′ 44.8″
"	13, "	87° 20′ 40.6″
"	23, "	87° 20′ 59.8″
"	29, "	87° 20′ 36.1″

Aug.	1, 1892	87° 20′ 53.6″
"	11, "	87° 20′ 52.0″
"	17, "	87° 20′ 50.8″
"	18, "	87° 20′ 41.2″
	Mean of 14 days	87° 20′ 50.2″

It will be seen that in the total fourteen days of observation the range of variability in vertical angles amounted to but 28″, indicating remarkable steadiness in atmospheric conditions.

The observations for height at other stations, although less numerous, are extremely satisfactory. The great uniformity of the final results for the height of the mountain as computed from observations at the five different stations is exhibited in the following table. The remarkably close agreement of these figures is satisfactory evidence that this determination of the height of the mountain is such as to leave little to be desired.

SUMMARY OF HEIGHT AND POSITION.

Mount Saint Elias from—	
North base	18,014 feet.
South base	18,012 "
Mount Hoorts	18,017 "
Ocean cape	18,012 "
Astronomical station	18,000 "
Height, adopted mean	18,010 "
Latitude	60° 17′ 35″
Longitude	140° 55′ 21.5″

It is interesting to note that in the light of the information of the last year or two, it can no longer be claimed that mount Saint Elias is the highest peak upon the continent. This distinction seems to belong to mount Orizaba, in Mexico, which has recently been measured by means of railroad levels and trigonometrically by Dr J. T. Scoville, of Terre Haute, Indiana. The height of this mountain, as obtained by Dr Scoville, is 18,314 feet. The character of the observations is such that it does not seem likely that this result will be found to be very many feet in error. It therefore appears to be entirely safe to say that Orizaba is the highest peak in North America, and that its altitude exceeds by two or three hundred feet that of mount Saint Elias. A detailed report on the latter mountain, together with the results of revised and complete calculations, will be published in due time.

THE IMPROVEMENT OF GEOGRAPHICAL TEACHING

BY

PROFESSOR WILLIAM MORRIS DAVIS

(*Presented before the Society February 3, 1893*)

The improvements needed in teaching geography in our schools involve a fuller investigation of the facts of the subject, a better knowledge of these facts by teachers, and a more skilful use of them in the processes of teaching. As a society, we are less concerned with the last two necessities than with the first, but I may briefly state my belief that skilful teaching goes along closely with fullness of knowledge. The third need will therefore be largely cared for when the second is supplied; but fullness of knowledge cannot be expected of a teacher while her understanding of the geographical features of the world and of our own country and of the home state in particular is gained only from the impoverished statements of the ordinary text-books, and while the original sources in which she may seek additional information are generally so few, so inaccessible, and so far below the standards of modern geographical research. It might truly be said that even if better sources of information were within reach little use could be made of them; for we must recognize the great difficulties under which the teachers in our public schools labor: the variety of subjects that they have to teach, the overlarge number of scholars in their classes, the restrictions that tend to smother their individuality, the fatigue following many tiresome duties, the smallness of salary by which freedom of action toward large opportunities is hampered. Would that some means of overcoming these difficulties might be devised! But at present it does not seem so practical to turn our action as a society in this direction as to look to remedying the fundamental need—the need of a fuller investigation of the facts.

It may not be generally recognized by our members that there is still great need of exploration close at home. It is not only in the further corners of the world that discoveries are to be

made. Nearly every state in our country must be much more carefully studied than it yet has been before its physical features will be made known to us. The geographical descriptions now accessible in print would be very gently characterized if only called "old fashioned." Where newer material has been published, it is generally fragmentary, brief, and imperfectly illustrated. The first elements of geographical study, the physical features of the earth—especially of its surface—still call for devoted investigation.

It is not simply a description of the forms of the land that is wanted. It is a recognition of the forms as dependent on structure and sculpture, and a comparison of like and unlike forms in a systematic manner. This requires special study, precisely as petrography does, and the desired end will not be gained until the work is placed in the hands of men especially trained for it. Having found this study an absorbing interest for several years past, I shall try to make my meaning clearer by introducing specific illustrations from New England.

Southern New England consists essentially of a gently inclined plateau, rising to 1,400 or 1,600 feet above sea level in the rolling uplands of western Massachusetts * and southwestern New Hampshire, and thence descending gradually southward and eastward to sea level at the coast. This inclined plateau is nothing more than a slightly tilted lowland of denudation, the product of long-continued destructive action of the atmosphere by which a once larger mass was worn down to a surface of moderate relief close to the baselevel of its time. The southeastern extension of the old lowland was depressed beneath the sea at the same time that its interior portion was elevated to form our New England plateau; the present coast line therefore lies roughly midway on the surface of old New England.

The continuity of the plateau-like uplands is interrupted in two ways; isolated mountains rise above it, and branching valleys sink below it. Mount Monadnock is a typical example of the former, with its bold summit more than a thousand feet above the surrounding plateau. When seen from a distance to the southwest, it rises in symmetrical triangular outline above the level skyline of its base. It is not a mountain of local construction, raised by upheaval above the mass of the plateau; it

* Nearly all the districts thus referred to in the address were illustrated by lantern slides.

is simply an unconsumed remnant of the greater mass of unknown dimensions and form, from which the old lowland was carved. When the lowland was uplifted, Monadnock and its fellows were raised with it. In my teaching, Monadnock has come to be recognized as an example of a distinct group of forms, and its name is used as having a generic value. A long paragraph of explanation is packed away when describing some other mountain as a "monadnock" of greater or less height.

The valleys by which the plateau is dissected have all been excavated since the uplift of the old lowland. Where the plateau is high the valleys are sunk deep below it. The Deerfield valley in northwestern Massachusetts is a full thousand feet deep. Where the uplift was small near the coast, the valleys are shallow. Where the rocks are hard, as is generally the case, the valleys are narrow, like that of the Deerfield above named. Where the rocks are soft, the valleys are wider; illustrating the general principle that mature and old forms are more rapidly developed on soft than on hard rocks. The Berkshire valley, excavated in limestone between crystalline rocks and schists, is six or more miles wide. The Connecticut valley, excavated in weak sandstones, is even wider, forming a valley lowland ten or fifteen miles from side to side and broadly dividing the plateau into eastern and western portions. Occasional beds of hard rocks, chiefly ancient lava flows, occur in the sandstone belt, and are much less eroded; they form ridges rising far above the lowland, and indeed still retain nearly the height of the adjacent plateaus.

Mount Holyoke, opposite Northampton, is a type of these ridges. It holds essentially the same relation to the lowland that Monadnock holds to the plateau. Both are residual mountains of harder rocks; but the two manifestly belong to different generations of geographical development.

It appears from this brief outline that our New England geography is of composite quality. The uplands with their residual mountains represent the closing stages of one generation or "cycle" of development; the valleys represent the more or less advanced beginning of another cycle. The distribution of our villages and our occupations, the lines of travel, and the movements of population may all be shown to depend largely on the topographic forms thus classified.

By following some plan of treatment such as this, it becomes possible to make just comparisons between different regions—

for example, a close correspondence may be found between our dissected New England plateau and the Hunsrück-Taunus plateau, through which the Rhine has cut its famous gorge below Bingen.* Here we find an even upland, with occasional eminences rising above it, and with deep valleys sunk below it. The eminences on the plateau are there, as with us, residuals of a once much greater mass, rising moderately above a base-levelled surface; the valleys are the work of a later cycle of development, inaugurated when the old baselevelled surface was uplifted to its present altitude. In all this, southern New England and the plateau of the middle Rhine are thoroughly homologous, but certain significant differences between the two regions should be noted: The plateau of the middle Rhine is so extremely flat-topped that it must be conceived as having advanced further in its first cycle of denudation than New England; indeed, it is the best illustration of a smoothly baselevelled area that I have found, and serves me as a type of such a form. On the other hand, its valleys are much narrower than ours; hence its second cycle must be regarded as less advanced than ours. Both regions possess composite topography, including similar elements; but the stages in the two cycles of development represented in each case do not precisely agree.

I cannot now delay to illustrate other elements of our New England topography, even in so brief a manner as the plateau, with its residual mountains and its initiated valleys, has been treated; but I may record my conviction, based on experience with scholars of different ages and with teachers in schools of various grades, that all our geographical features, when studied out in a manner similar to that outlined above, become luminous in comparison with the obscurity of the conventional accounts in our school books. The drowned valleys that form our bays, the drowned rivers that form our estuaries, at once gain a new meaning when thus explained; and it is not a little remarkable to see how little recognition there is in general teaching of the control exerted by depression of the land on the form of its coast line. Look at Narragansett bay, the fiord of the Thames at Norwich, of the Connecticut above Saybrook, of the Housatonic towards Birmingham, of the Hudson even up to Albany—all "drownded," like Pegotty's brothers at old Yarmouth; yet

* Excellent lantern slides of this picturesque region may be had from dealers; much better, in fact, than can be found for our scenery at home, although the latter is much the more important for our schools.

what school boy ever hears our coastal rivers thus simply and rationally characterized? Look at the sprawling outline of Greece, and ask our classical scholars if they describe it as a rugged mountainous region standing in the Mediterranean up to its knees; and yet how effective is the homely comparison!

It is the same with the results of glacial action. The text books of geography are practically silent on this important topic; yet many features of glacial origin must be known in fact to every boy who has rambled through the woods on his half holidays. Our gravel ridges and mounds and our sand plains may be reckoned as characteristic of our home geography as Lowell's "Bigelow Papers" are of Yankee dialect. It is a pity that they are not duly mentioned in our schools and compared with that suggestive fund of fresh material brought by Russell from Alaska and so honorably associated with the name of our society. The comparison that may be drawn here is as fair as that instituted already between New England and the plateau of the middle Rhine, but the two comparisons are of different kinds. The comparison of the two plateaus associates distant regions that are now alike. The comparison of New England and Alaska employs the present of the latter region to illustrate the past of the former; and this style of comparison is extremely suggestive in geographic study.

For several years past, some of my more advanced students have chosen as subjects for their theses the physical geography of various states with which they were more or less familiar from residence or field observation, or with which they wished to become familiar. They have thus had occasion to search the literature of each state for accounts of its physical features, and the search has generally been without large reward. The practice has been useful, but the product has not been great. It is this want of material that convinces me that nothing less than the direct exploration of our home country, with the single object of investigating its topographical development, will secure the facts that are now needed in geographical teaching; and thus we return to the general question that was laid aside while southern New England was before us.

It is of course impossible in the limits of this address to give a full statement of the scheme of systematic geography, the appreciation of which seems to me essential in the desired exploration and investigation; but there are two leading principles

which I may outline, since without them no progress can be made: The first is that every land form passes through a comparatively systematic series of changes from its youth, when its form is defined chiefly by constructional processes, past its maturity, when the processes of sub-aerial sculpture have carved a great variety of mouldings and channellings, toward its old age, in which the accomplishment of the full measure of denudation reduces the mass essentially to baselevel, however high it may have been originally. I have become accustomed to call this unmeasured time a geographical cycle. It may be long for a structure of hard rocks, or shorter for a structure of weak rocks; but in both the sequence of immature, mature, and senile forms is essential. The particular expression of these forms varies with the structure of the mass concerned; but for every structure there is an appropriate sequence of young, mature, and old features.

It is therefore important to determine in accordance with this fundamental principle the stage in which any given area stands in its life's journey. The standard descriptions of many of our states gives no such account of their topographic forms, and the student or teacher who seeks it has little reward. The account is needed not only because the reader can gather from it a better understanding of the relations of a region to the rest of the world, but also because such an account enables him to appreciate much more closely and more easily the actual forms of the region itself.

A second important principle is in a measure a corollary of the first: At any time during a geographical cycle a land area may be disturbed by depression or elevation. A new relation is then established with the baselevel of drainage, and a new cycle of denudation is introduced. The forms developed by denudation in the first incomplete cycle then become, as it were, the constructional forms of the new cycle, and from those as a beginning the forces of denudation go on anew. The combination of the topographic features developed in the two cycles produces what I have called "composite topography," and this is of extremely common occurrence—for an example, we may refer again to the dissected plateau of southern New England. The upland with its residual mountains is the product of an earlier cycle; the valleys are the work of a later cycle; the glacial features may be referred merely to a short-lived climatic episode late in the second cycle, so brief was the occupation of

the country with ice compared to the time required for the excavation of the valleys in the uplifted plateau.

Geographical descriptions and the appreciation of them are greatly advanced by a recognition of these principles; they are essentially simple conceptions, but the variety of their application is infinite. The work of more than two cycles may not infrequently be recognized. Thus, in Pennsylvania the crest lines of the Appalachian ridges are remnants of an uplifted and almost consumed plateau of Cretaceous denudation, of which only the hardest parts now remain; the open valley lowlands between the ridges are the product of Tertiary excavation in the uplifted plateau; the narrow trenches, in which the rivers traverse the lowlands, are of post-Tertiary origin. Many points of view may be selected on the Susquehanna, where these three elements of the landscape stand out with much distinctness, and the pleasure of their contemplation is greatly increased by the recognition of their distinct conditions of origin in successive geographical cycles or during successive uplifts of the land.

What is the most effective way in which we can promote the advance of geographic investigation and secure accounts and illustrations of our home country in accordance with a systematic and scientific method? It has seemed to me that appeal might be profitably made for the coöperation of the directors of the various state geological surveys.

I therefore propose to ask the directors of our various state geological surveys to devote annually a part of their funds to the study of the physical features of their domains in the light of modern geographical science, provided that the terms of their appropriation bills will allow them to cover this side of the geological field; and if not, I shall hope that special appropriations of moderate amount may be made for this particular purpose. Experts should be employed for this work, as they are now in paleontology and petrography. The results thus gained would appear in successive annual reports, brief at first, increasing in scope as opportunity offers, and setting forth the larger and smaller elements of the topography in such simple style and with such comparisons and illustrations as should be of immediate value to teachers in grammar schools and high schools. The state boards of education might secure special reprints of these geographical chapters at very moderate cost for distribution as state products to all public libraries and to all

public schools of the higher grades; much in the same way as the energetic commissioners of the topographic survey of Rhode Island have secured the distribution of their state map free to all their public schools and libraries. The legislature would soon see, from the employment of these geographical chapters year after year by thousands of teachers, the appreciation that this hitherto undeveloped economic field might receive from those occupied with the advance of public education, and assured support would then be given to the work, even on enlarged scale. By some such practical steps we may secure a material advance in the quality of geographical instruction.

During the past year, I have had many illustrations of the need of material of geographical of the kind here referred to. Teachers in our public schools are well aware that they have not now the fuller account of the facts that they would enjoy; and yet they know not where to turn to find what they need. Many teachers, principals, and superintendents with whom I have spoken admit at once that the books to which they now have access are quite insufficient to satisfy their wants, and they listen gladly to any feasible plan that will provide a more extended and more scientific description and explanation of the facts of geography near at home, with which they have to deal from their earliest to their latest teaching. Geologists or geographers who are already acquainted with our local geography from personal experience can perform a grateful service to the schools by preparing elementary accounts of the regions with which they are familiar, and such books as these should be greatly multiplied; but, so far as I have been able to learn, it is only the smaller part of our country that is now known well enough to those who can be prevailed on to write elementary books, and hence the importance of actual geographical exploration in order to supply our teachers with what they need. If some such plan as the one proposed above were put in operation, it might come to pass in a decade or two that the graduates of our common schools would not be so blinded as they now are to the facts of their home geography.

HARVARD UNIVERSITY, CAMBRIDGE, MASS.

AN UNDISCOVERED ISLAND OFF THE NORTHERN COAST OF ALASKA

(Presented before the Society April 28, 1893)

I—BY MARCUS BAKER

On a map of the polar regions published in Gotha eleven years ago, land is indicated as existing about 150 miles north-northeastward from point Barrow, the northernmost point of Alaska. The position of this land is latitude 73½° N. and longitude 153½° W. of Greenwich. I have not succeeded in finding this land indicated on any other map, neither have I found any published statement respecting it.

In the summer of 1849, Kellett and Moore, in the Arctic search vessels *Herald* and *Plover*, cruised in the Arctic ocean, between point Barrow and Herald island, searching for Sir John Franklin. It was during this cruise that Herald island was discovered and landed upon, and the high peaks of what we now know to be Wrangell island were seen to the westward. In the map accompanying their report* an "appearance of land" is shown in latitude 72½° N., longitude 161½° W. of Greenwich, being about 130 miles northwest of point Barrow. On a small map accompanying Osborn's "Stray Leaves from an Arctic Journal," land is indicated in the same locality, as also on an undated map published by Longman in London in 1850 or 1851.

Russian hydrographic chart number 1495, published in 1854, also shows land here, with the note "Indications of land according to report of the English sloop *Plover* in 1849."

These four maps are the only ones, out of a considerable number examined by me, which show this appearance of land, and they are all obviously derived from the same authority, viz, Kellett and Moore.

In Kellett's narrative the only reference to this appearance of land is the following statement at p. 14:

*Additional papers relative to the Arctic expedition, etc, presented to both Houses of Parliament by command of Her Majesty. Folio London, 1852. Pl. 15, *ad fin.*

"This was our most northern position, lat. 72° 51′ N., long. 168° W. The ice, as far as it could be seen from the mast-head, trended away W. S. W. (compass), Commander Moore and the ice-master reporting a water sky to the north of the pack, and a strong ice-blink to the S. W."

It appears obvious from this statement that the evidence of land existing here is very slight. The appearance of land is omitted from all the late maps. It does not appear on the British Admiralty charts, nor on the charts of our own Hydrographic Office or Coast Survey. Indeed, on hydrographic chart 68, a sounding of 54 fathoms, muddy bottom, is shown in this place. It is clear, I think, that land does not exist here.

Now, on the circumpolar map first mentioned the land shown north-northeast of point Barrow is about 150 miles northeast of the place where Kellett's "appearance of land" is shown. I had supposed before examination that these indications referred to the same thing, but, having made an examination, I am of opinion that the indication of land shown on the circumpolar map is not derived from Kellett and Moore, but from some unpublished source of information.

That there is an undiscovered or rather unvisited land somewhere north and east of point Barrow is a matter of common talk among the whalers who annually visit this region. Captain John Keenan, of Troy, New York, master of the whaling bark *Stamboul*, of New Bedford, reports that he and all his crew saw it while on a whaling voyage some time during the seventies. The Eskimos have traditions of this land and of a visit to it by their fathers "long ago."

The known facts respecting this hypothetical (or should we not say real?) land are exceedingly meager and all unpublished. It has therefore seemed to me desirable to put these few facts on record, and that no place was more suitable than the journal of a society devoted to the increase and diffusion of geographic knowledge.

The facts have all come to me through my old friend Captain E. P. Herendeen, who, at my request, has written the account to which these remarks are intended merely as an introduction. Captain Herendeen, a native of Woods Holl, Massachusetts, has been for many years engaged in whaling, having entered the Arctic in pursuit of whales as early as 1850, and has since then made more than a score of voyages to this region. I have had the pleasure of making three voyages to the northern Pacific and

Arctic oceans in his company. In 1882–'83 he was a member of the United States Signal Service party stationed at point Barrow. He is well acquainted with all the natives on the Arctic coast from the East cape of Asia eastward to the mouth of the Mackenzie river. He speaks their language and is universally known to the natives of that region under the name of "Heretic." From the natives and through Captain Keenan of the whaling fleet he has obtained the following information, which he has kindly written out for the National Geographic Society.

I beg to suggest the desirability of calling this very little-known land *Keenan island.*

II—BY CAPTAIN EDWARD PERRY HERENDEEN

Among the many traditions of the point Barrow Eskimo the following is not without geographic interest:

Since no account is kept by them of the lapse of time, it is impossible to fix a date to any story related by them previous to the life of their father or grandfather. Their simple answer to any question regarding the date of these occurrences is always the same, "eidrárnee" (long ago). Our story is this: An Eskimo was out on a whale hunt with his umiak and crew (in April or May). Venturing much farther than their companions and being encompassed by ice, they were carried away to the north and east by the moving pack until at last they came in sight of a strange land. After many hardships and the death of most of the crew, some at last reached the mainland, their own beloved "Nunah," greatly exhausted, and related their adventures to wondering listeners. They told of times when starvation grimly threatened and when the timely catching of a seal or killing of a bear saved them from a dreadful fate, and the skins furnished material to repair their worn garments.

These tales, by whomsoever related, seem to bear testimony to one point, viz, of land somewhere to the north and east of point Barrow, which has been seen by some of these people under such circumstances of hardship, distress and loss of life as to have fixed the event in their minds and been related by father to son for perhaps many generations. It is often told that natives wintering between Harrison and Camden bays have seen land to the north in the bright, clear days of spring.

In the winter of 1886–'87, Uzharlu, an enterprising Eskimo of Ootkeavie, was very anxious for me to get some captain to take

him the following summer, with his family, canoe and outfit, to the northeast as far as the ship went, and then he would try to find this mysterious land of which he had heard so much; but no one cared to bother with this venturesome Eskimo explorer. So confident was this man of the truth of these reports that he was eager to sail away into the unknown, like another Columbus, in search of an Eskimo paradise.

In the winter of 1887 several of the most intelligent of the cape Smyth Eskimo came to me about dusk of the evening of February 15 and reported that three strange men had come up from the southwest along the shore ice, and appeared very weary, but on coming opposite the village (which could not have been seen by the travelers before) they quickened their pace, turned abruptly off shore, and disappeared in the ice-pack. It was just as the sun was setting, and the strangers could be seen distinctly, but not until they had gotten into the rough ice did it occur to these people standing on the bank that these three wanderers were strangers indeed; and the more they talked the matter over the more wonderful it seemed that any tired hunter should pass their village without stopping for rest and refreshment. It was evident that they turned away in fear when they saw the village and the people standing on the bank. Who could these men be who turned away from their hospitable village, where food and a warm welcome awaited them? They reasoned that every man on the coast from point Hope to point Barrow was known to all the others, and knew he would be welcome to food and shelter. The more they talked, the stranger it seemed, until the conclusion was reached that these were "inu tumuktua," (lost people,) and of course their home must be the mysterious land of their fathers' tradition. As a proof of this they said these three men wore white clothing, which was most likely made of white bear skins, while the Eskimo of the coast wear brown clothing made of reindeer skins.

Another point in favor of their assertion was that these men had no guns, which fact was noted before they turned off shore into the pack. They had spears and a coil of seal line, and used the spears as walking-sticks as they plodded wearily along.

The circumstance was most strange. Every man in the village of Ootkeavie gave an account of himself that evening, and I took the trouble to send to point Barrow the next morning, but none of them had been in that vicinity or were able to throw any light on the subject. From my knowledge of the Eskimo, I am

sure no one acquainted would have passed a village without stopping. It was near night, yet these men in evident alarm turned off shore into the ice pack and were never seen again.

I made arrangements to go out in the morning and trace these men and solve the mystery; but the morning dawned with a fierce blizzard, causing the abandonment of the search, and left us wondering whence they came and whither they went.

The only report of land having been seen by civilized man in this vicinity was made by Captain John Keenan, of Troy, New York, in the seventies. He was at that time in command of the whaling bark *Stamboul*, of New Bedford. Captain Keenan said that after taking several whales the weather became thick, and he stood to the north under easy sail, and was busily engaged in trying out and stowing down the oil taken. When the fog cleared off, land was distinctly seen to the north by him and all the men of his crew; but, as he was not on a voyage of discovery and there were no whales in sight, he was obliged to give the order to keep away to the south in search of them. The success of his voyage depended on keeping among whales.

This fact was often discussed among the whalemen on the return of the fleet to San Francisco in the fall. The position of Captain Keenan's ship at the time land was seen has passed from my mind, except that it was between Harrison and Camden bays.

A letter addressed to Captain Keenan by the writer in February, asking for more definite information as to date and position of his ship and other points of interest, failed to reach him and was returned.

III—BY GENERAL A. W. GREELY

Mr Baker's notes on "An undiscovered island off the northern coast of Alaska" are extremely interesting. I am, however, unable to agree with Mr Baker in the belief that land exists in the polar sea between point Barrow and Melville island.

On my attention being called to the paper and German map of 1882, I did not at first recall that I had before seen charts marked with the signs of land referred to. On later consideration I remembered maps containing this knowledge, and have since examined all maps of arctic America from 1844 to 1858 in my private collection and one or two others accessible elsewhere.

It is interesting to note to what extent these signs of land were credited by map-makers of that period. For many years

chart number 260 of the hydrographic office of the royal navy was the standard map of the polar regions. So far as I have learned, there were but two such charts between 1835 and 1886, one being that of 1835, the other bearing date of December 24, 1855. The chart of 1835 had no such land upon it, nor did the *first* edition (see Scoresby's "Search for Franklin," London, 1852), which bore the note, "corrected to 1849," and such land disappeared from the corrected chart of 1855. It appears that corrections were constantly made on this chart of 1849, some, even of the most important character, without additional foot-notes. This is strikingly illustrated by a copy of the chart published in the Parliamentary Blue Book referred to by Mr Baker (folio, London, 1852, plate 15). Although the chart has the engraved note, "corrected to 1849," yet there appear thereon the important discoveries of Admiral Inglefield made in Smith sound during the summer of 1852, which were not known in Great Britain until his return in November of that year. It is probable that these discoveries were added to the chart in the final revise, just as the report was going to press. Sir John Barrow, the great authority on Arctic discoveries, in his polar chart of 1846 ("Voyages to the Arctic Regions," London, 1847) enters no note regarding the new land. The land referred to, so far as I know, first appeared on the polar map in Richardson's "Arctic Searching Expedition: A Boat Voyage through Ruperts Land," Longman, London, 1851, this probably being the Longman undated chart of Mr Baker. Later, in chronologic order, it appeared in Osborn's "Stray Leaves from an Arctic Journal," London, 1852; "Additional Papers Relative to the Arctic Expedition," etc, London, 1852 (evidently printed after November 1, 1852), both quoted by Baker.

In the *Revue Britanique* of December, 1853, (Paris,) was published a map of the polar regions, with the legend "land seen" in 72° 30′ N. 161° W. To the southwest of this land is a dotted line marking the limits of the polar ice in 1849. This evidently is the line of ice charted by the *Plover* in 1849. Then follows the Russian hydrographic chart number 1495, 1854, quoted by Baker, with the note, "Indications of land according to the report of the English sloop *Plover* in 1849." With Mr Baker I have searched in vain for corroboration of this entry.

The *Herald* was in company with the *Plover*, and the parliamentary report finds confirmation in Seeman's "Voyage of the *Herald*," London, 1853, vol. ii, page 106:

"It was a fine, clear night. * * * At midnight the latitude was obtained by the inferior passage of the sun, 72° 10′ 30″ N. * * * (29 July, 1849.) * * * Our soundings had gradually increased to thirty-five fathoms of soft blue mud. * * * This position was our most northern one latitude 72° 51′ N., longitude 163° W. * * * Commander Moore (of the *Plover*) and the ice-master reporting a water sky to the north of the pack, and a strong ice-blink to the southwest."

The evident incorrectness of the land charted is shown by the experience of Collinson in 1850, when the general line of the heavy pack-ice was somewhat farther northward, extending from southeast to northwest from 73° N. in 160° W. to 72° 40′ N. in 165° W. Collinson, on August 26, 1850, was in 73° 23′ N., 164° W., and on August 28 was in 72° 35′ N., 161° W., thus having passed directly over the position of the land charted as above. On the 17th he was in 72° 45′ N., 159° W.; August 22 in 72° 25′ N., 158° W.; August 21 in 72° 10′ N., 153° W. Collinson says:

"August 17 (1850). * * * The fog cleared away at 1 p. m., and we found ourselves in a lane of clear water ten miles wide, with a clear sea to the N. E. * * * Our observations placed us 100 miles N. W. by N. from point Barrow, and we found 45 fathoms of water, muddy bottom."

"21.—Had traced pack from 72° 45′ N. in 159° W. for 275 miles to S. E., to 71° 42′ N., 154° 30′ W."

"Aug. 28.—Here we reached our furthest point north in 73° 23′ N. and longitude 164° W. In the afternoon, the pack edge trending more to the southward, we got much encumbered by endeavoring to get through it to the *eastward*, straining our eyes in that direction in the hope of seeing either *land* or water."

On August 18, 1850, McClure was in 70° 48′ N., 138° W., with no sign of land.

The weight of opinion in the following few years was decidedly against there being such land, as shown by its omission from the charts of arctic America in the following-named works:

Scoresby's Search for Franklin, London, 1851.

Hooper's The Tents of the Tuski, London, 1852.

Mangle's Arctic Searching Expedition, 2d edition, London, 1852, where Peterman's Search Map is reproduced (there being no map of the first edition, London, 1851).

Sutherland's Voyage to Baffin's Bay and Barrow Strait (Peterman's map), London, 1852.

Further Correspondence and Proceedings Connected with the Arctic Expedition, presented to Parliament, London, 1852 (Peterman's map).

Lieutenant S. Gurney Cresswell's map, dated May 15, 1854

Brande's Sir John Franklin, map by Langes, Berlin, 1854.

Armstrong's Northwest Passage, London, 1857.

Osborn's McClure Discovery of the Northwest Passage, London, 1856.*
McDougall's Eventful Voyage of H. M. S. *Resolute*, London, 1857.
Brown's Northwest Passage, 2d edition, London, 1860, which contains a map by Arrowsmith, 1858.

It thus appears that the "*Plover*" land is a myth, Mr Baker agreeing with me on this point.

The Keenan land lies, however, somewhat east of the mythical land already disposed of, being indefinitely located between Harrison and Camden bay, north of the 72d parallel. The uncertainty of position of whalers is well known, as no care is given to longitude or other astronomical observations.

Since definite data are lacking, the subject can be approached from another standpoint, that of the depths of the adjacent seas. It will be recalled by those familiar with the Arctic ocean to the north of Bering strait region that it is a very shallow sea. In one direction only does it deepen, and, unfortunately for Keenan island, it is in that particular quarter.

In my opinion, the great improbability of land in the region mentioned appears from an examination of the soundings of the sea from the northwest to east of point Barrow, which are as follows, the position being approximate: 172° W. longitude, 73° 5′ N. latitude, 78 fathoms; 159° W., 72° 6′ N., 133 x (x indicates no bottom); 155° W., 72° N., 145 x; 140° W., 70° 5′ N., 190 x; 139° W., 70° 3′ N., 145 x; 126° W., 70° 5′ N., 110, and 124° W., 74° 5′ N. (on the very coast of Banks land), 45 fathoms.

The above observations show that the parts of the Arctic ocean passed over and most nearly adjacent gradually and interruptedly increase in depth from the west, from the south and southeast toward the reported land, attaining in its neighborhood the greatest known depth of water to the northward of Bering strait. That this condition of depth is not strictly local but extends uninterruptedly northward is proved conclusively by the very heavy ice met with by Collinson and McClure between point Barrow and Banks land, which ran upward of 200 feet in thickness. As this thick ice is unquestionably of land origin, from an ice-capped country of considerable extent, there must be deep water for its transition. It is possible, but not probable, that the southern edge of this land lies so close to arctic America.

*This omission is striking, inasmuch as Osborn inserted it in his "Stray Leaves from an Arctic Journal," 1852.

THE GEOLOGIST AT BLUE MOUNTAIN, MARYLAND

BY

CHARLES D. WALCOTT

Most of the summer visitors at Blue mountain, Maryland, give little thought to the origin of the mountain, nor how it came to be a ridge rising so boldly on the west from the Cumberland valley and on the east overlooking the mountain valley to the foot of the Catoctin ridge, which rises above the plain stretching thence southeastward to Washington.

During the summer of 1892 the writer discovered that the rocks forming the crest of the Blue ridge belong among the oldest formations deposited in the Appalachian trough, since they carry types of life occurring in the most ancient fossiliferous rocks on the North American continent that are distinguished by a recognizable fauna; the geologic structure also shows that these rocks rest upon the ancient sea-bed of the Appalachian trough, and that they are of the same relative geologic age as the Cambrian rocks that occupy an equivalent stratigraphic position in Vermont, New Jersey, New York, Virginia and Tennessee.

The recent work of Dr G. H. Williams demonstrates that, with one partial exception, the older crystalline rocks underlying the Cambrian strata have hitherto been misinterpreted and misunderstood by the geologists who have studied them. Instead of being sedimentary formations originally deposited in the sea-bed, they are volcanic rocks and almost identical with the lavas found in Nevada, Wyoming and in many portions of the Rocky mountain region. This discovery proves that the laboratory of nature produced a certain type of volcanic rock almost at the beginning of the evolution of the North American continent, and again produced the same type many millions of years afterward on the western side of the continent.

The broad mountain crossing the Pennsylvania-Maryland line includes eastern and western border ridges and an intervening

valley. On the western or Blue Ridge side it is built up of sedimentary rocks originally deposited in the sea on the bottom and, it may be, the side of the Appalachian trough. In the intervening valley it consists to a considerable extent of eruptive rocks, which poured out as flows the ancient land surface prior to the existence of the Appalachian trough and before the deposition of the stratified rocks which so largely form the North American continent within the limits of the United States. The elevated eastern side forms the Catoctin ridge, which is capped by a compressed fold of the old shales and quartzites. Both ridges continue south of the Maryland line toward Harpers Ferry and far into Virginia as compressed synclinal folds of the Cambrian rocks, resting on the rocks of the ancient Appalachian trough, the older rocks and the more recent rocks having been involved in the same series of folding. In addition to this folding, numerous thrusts of one mass of rocks upon another are to be found all along the Blue ridge, especially north of the Pennsylvania-Maryland line, in the northern extension of Blue mountain, or the South mountain of Pennsylvania. In some instances the ancient eruptive rocks have been thrust westward, so as to rest upon and above the more recent sandstones and shales which were originally deposited upon them in the bottom and along the shore of the Appalachian trough. Often the pressure has cleaved the massive lavas and formed slates and shales that appear like those deposited in quiet waters. The result of this has been to complicate the geologic structure and topography of South mountain and the Blue ridge, and to make the region one of great interest to both professional and amateur geologists. Erosion has aided their study by cutting away thousands of feet of strata from above the present mountain area and adjacent valleys, and thus laying bare a portion of the ancient shoreline of the Atlantic coast area of Cambrian time and of the foundation upon which much of the present continent is built.

The history of the Blue ridge and its rocks as now interpreted is essentjally as follows:* It began long after the first known primitive rocks of the earth were raised into plateaus and ridges to form the platforms of the present continents. At the close of the periods in which the earlier crystalline rocks of the continent were formed, and also the great masses of bedded rocks beneath those containing the Cambrian or oldest known fauna,

* See Am. Journ. Sci., vol. xliv, 1892, pp. —.

that portion of the North American continent then above the sea is thought to have consisted of (1) a large part of what is now the British possessions; (2) a long, broad mountain area (Atlantic) extended southwestward from Newfoundland to the present site of the Gulf of Mexico and it may be the West Indian archipelago, (3) and one or more areas (Pacific) on the western side of the continental plateau, on the line of the present Rocky mountain and Sierra Nevada ranges.* The eastern or Atlantic area and the bed of the interior sea toward the west, in what may be called the Appalachian trough, were then formed of variouss kind of rock, including granite, schists of various kinds, crystalline and unaltered sedimentary rocks and, in some localities, of great masses of volcanic material that had been poured out over the surface in very much the same manner as were the relatively recent lavas found in the vicinity of the Yellowstone National Park and in various parts of the Rocky mountain region.

The waves of the interior sea wore away from the western shore of the Atlantic land area various rock materials and deposited them along with that brought in by the brooks and rivers as layers of sand and gravel on the sea-bed all the way from the present site of the Saint Lawrence river to Alabama. In these deposits fragments of the volcanic rocks, schists, etc, were mingled, and spread out in sheets. At times the supply of material was very fine and formed thin layers of mud that afterward consolidated into shales and slates. After a deposition of several thousand feet of this character of materials the water deepened, probably by the subsidence of the bed of the sea and calcareous muds were deposited during a great interval of time until in places they reached the thickness of several thousand feet. These now form the limestones found in the Cumberland and Shenandoah valleys and their extensions northward to Canada and southward to Alabama. All along this ancient coast line, from Labrador to Alabama, various forms of marine life existed, and their hard parts, such as shells of crustaceans (allied to the living king crab) and other organisms, were buried in the mud and sand.

The deposition of sediments in the sea, immediately west of the Atlantic area, continued until from 12,000 to 40,000 feet in thickness were piled over the ancient sea-bottom, layer upon

* See article on the North American Continent during Cambrian Time, in Twelfth Ann. Rep. U. S. Geol. Survey, 1892, pp. —.

layer, sometimes of one kind of sediment and sometimes of another. These are now found as layers of sandstone, limestone, coal, shale, slate and various combinations of sandstone, shale, etc. With the close of the first great age (Paleozoic) in sedimentation in the Appalachian trough, the earth's forces again became active, and sufficient pressure was exerted from the Atlantic coast side of the continent to raise this great mass of sediments above the sea and to fold it in ridges and hollows, very much as layers of paper or cloth would fold from pressure applied to the edges of the layers if they were partially confined above and below. This was varied, however, in the great rock-masses by the frequent shearing on the line of the folds and the thrusting of masses of rock one over the other, as cards shift over each other under pressure. One of these folds, with minor folds within it, has by subsequent agencies been carved into the Blue ridge.

The epoch of folding was several millions of years ago; so long since that sufficient time has elapsed for thousands of feet of sediments to be deposited in the interior lakes and seas of the North American continent and for animal life to develop from the then highest types of fish and reptile to the higher mammals, at the head of which man stands today.

During the thousands of centuries since the first great Appalachian uplift, the rain, frost, and snow have been at work sculpturing the old land surface and slowly working out the mountains, valleys, and plains. It is not improbable that the process of mountain uplift and that of wearing away the mountains to a relatively level area (baselevel of erosion) may have taken place several times, the intervals of rest between the wearing away of the highland and mountains and the succeeding epoch of uplift being of long duration—so long, in fact, that centuries might pass without effecting a marked change in the relations of the land and sea.

It was not far back, geologically speaking, that the Blue ridge was a part of, and not distinct from, a great plain that was broken by low hills and valleys and drained by streams flowing into a river that occupied relatively the same position that the Potomac does now. The continent was then at a lower level in relation to the sea, and it was not until it became elevated that the Potomac began to cut down into its bed in the old plain and carry out to the ocean the material which filled the areas now

represented by the Cumberland and Shenandoah valleys. As this process continued and the river lowered its channel the Blue ridge began to take shape as a distinct feature in the landscape. Slowly but surely the softer beds were broken up, dissolved and carried away, and the harder beds of rock began to project above the ancient plateau. It was only the question of which beds of rock could the longer resist the forces of rain and frost to determine the location of mountains and valleys.

We have thus hastily sketched the evolution of a portion of the continent and the evolution of one of its topographic features as shown by the Blue ridge. This evolution has gone on everywhere. Every ridge, however small; every valley, whether shallow or deep, narrow or broad; every stream-channel all over the surface of the continent, has its history back in the past, and it is by the studies of the geologists that we learn something of that history. It is now nearly forty years since William B. and H. D. Rogers discovered many elements of the structure of the Appalachian mountains; but it was not until within the last few years that the means of correlating and thus interpreting more accurately the structure of the various mountains formed by the lower and oldest series of the sedimentary rocks have been obtained.

During the deposition of the 40,000 feet of sediments in the Appalachian trough many millions of invertebrate animals lived and died along the shore and on the sea-bed. Those that lived in the earlier epochs became extinct and new forms succeeded them, and these in turn were succeeded many times during the vast interval between the first deposit and the closing one before the epoch of the last Appalachian uplift and folding. The remains of the various groups of life now afford the data by which the geologist correlates the various disturbed and often separated masses and determines what were their original relations to each other.

There are hundreds of local details yet to be studied and interpreted, and the work will be done by those who love to study the record of creation in the fragmentary book of nature, where all is written that we know of the past before barbaric man began his imperfect record by myth and legend.

THE GREAT POPULOUS CENTERS OF THE WORLD

BY

GENERAL A. W. GREELY

The astonishing growth of urban population in the United States during the past decade induced the writer to cursorily examine the tendencies of other countries in this direction, which developed facts indicating very clearly that it is a general and not local migration.

In conducting the research, lists were made of the five hundred or more cities in which the population exceeds fifty thousand, in which doubtless live one-fifth of the fourteen hundred and eighty millions which make up the population of the world. From this list have been selected the hundred cities having the greatest number of inhabitants, and, with one exception (Canton,) no place has been included unless its population has been determined by census. In general, the figures here given agree with those in that most excellent publication, "The Statesman's Year Book." The census year is not uniform, and as it may be said that the growth of cities outside of the United States lies, in general, between one and two per cent annually, the order of rank here given is not absolute.

Of the five hundred cities with a population above fifty thousand, the countries having the greatest number are: United States, 85 India, 76; Great Britain, 72; Germany, 47; Russia, 34; France, 33; Japan, 17; Spain, 16; Austria-Hungary, 15; Italy, 14. Four-fifths of all are situated in these ten countries and one-sixth in the United States. No less than three of the ten cities having a million of inhabitants are in the United States, and also four of the sixteen great population centers of the world. This last designation is here given to cities of more than three-fourths of a million, this dividing line in rank being at once apparent, as there are practically no cities with population between half a million and three-fourths of a million.

XUM

List of the most populous Cities by last Census.

Rank.	Census year.		Population.
	1891	"Greater London," England (outer ring)...	5,633,332
1	1891	London, England (registration).....	4,211,056
		London, England (central area).....	1,022,529
2	1891	Paris, France.....	2,447,957
3	1890	"Greater New York," United States*.....	3,250,000
	1892	New York, United States.....	1,801,639
4	....	Canton, China (estimated).....	1,600,000
5	1890	Berlin, Germany.....	1,579,244
6	1891	Vienna, Austria.....	1,389,684
	1891	Vienna, Austria.....	† 1,364,548
7	1891	Tokio, Japan.....	1,161,800
8	1890	Chicago, United States.....	1,099,850
9	1890	Philadelphia, United States.....	1,046,964
10	1889	Saint Petersburg, Russia (in winter).....	1,003,315
	1889	Saint Petersburg, Russia (in summer).....	845,315
11	1892	Brooklyn, United States.....	957,163
12	1885	Constantinople, Turkey.....	873,565
13	1891	Calcutta, India (excluding Howrah, 129,800).	840,130
14	1891	Bombay, India.....	804,470
15	1891	Glasgow, Scotland.....	792,728
		Glasgow, Scotland.....	† 565,714
16	1884	Moscow, Russia.....	753,469
17	1891	Buenos Ayres, Argentine Republic.....	561,160
18	1891	Liverpool, England.....	517,591
19	1890	Budapest, Hungary.....	506,384
20	1891	Manchester, England.....	505,343
21	1891	Melbourne, Victoria.....	491,378
22	1891	Osaka, Japan.....	483,609
23	1891	Brussels, Belgium.....	482,268
24	1887	Madrid, Spain.....	472,228
25	1891	Warsaw, Russia.....	465,272
26	1881	Naples, Italy.....	463,172
27	1890	Saint Louis, United States.....	451,770
28	1891	Madras, India.....	449,950
29	1890	Boston, United States.....	448,477
30	1890	Baltimore, United States.....	434,439
31	1891	Birmingham, England.....	429,171
32	1890	Amsterdam, Netherlands.....	417,539
33	1891	Lyons, France.....	416,029
34	1891	Marseilles, France.....	403,749
35	1891	Sydney, New South Wales.....	386,400
36	1891	Copenhagen, Denmark.....	375,251
		Copenhagen, Denmark.....	† 312,387
37	1882	Cairo, Egypt.....	368,108
38	1891	Leeds, England.....	367,506
39	1890	Leipzig, Germany.....	353,272
		Leipzig, Germany.....	† 293,525
40	1891	Dublin, Ireland (Metropolitan police dist.).	361,891
		Dublin, Ireland.....	† 254,709
41	1890	Munich, Germany.....	348,317
42	1890	Breslau, Germany.....	335,174
43	1890	Hamburg, Germany.....	329,923
44	1890	Mexico, Mexico.....	329,535

* Mr. Henry Gannett's figures; this volume, p. 31.

† Excluding suburbs.

List of the most populous Cities—Continued.

Rank.	Census year.		Population.
45	1891	Sheffield, England	324,243
46	1890	Odessa, Russia	313,687
47	1891	Haidarabad, India	312,390
48	1890	San Francisco, United States	298,993
49	1884	Kioto, Japan	297,527
50	1890	Cincinnati, United States	296,908
51	1881	Milan, Italy	295,543
52	1890	Cologne, Germany	281,273
53	1892	Buffalo, United States	278,727
54	1890	Dresden, Germany	276,085
55	1872	Rio de Janeiro, Brazil	274,972
56	1881	Rome, Italy	273,268
57	1891	Lucknow, India	273,090
58	1887	Barcelona, Spain	272,481
59	1890	Cleveland, United States	261,353
60	1891	Edinburgh, Scotland	261,261
61	1891	Belfast, Ireland	255,896
62	1890	Bordeaux, France	252,415
63	1890	Stockholm, Sweden	246,564
64	1878	Lisbon, Portugal	246,343
65	1890	New Orleans, United States	242,039
66	1890	Pittsburgh, United States	238,617
67	1890	Washington, United States	230,392
68	1881	Turin, Italy	230,183
69	1891	Antwerp, Belgium	227,225
70	1891	Benares, India	222,520
71	1876	Bucharest, Roumania	221,805
72	1891	Bristol, England	221,665
73	1891	Hong Kong, China	221,441
74	1891	Montreal, Canada	216,650
75	1891	Bradford, England	216,361
76	1891	Nottingham, England	211,984
77	1890	Rotterdam, Netherlands	209,136
78	1890	Detroit, United States	205,876
79	1887	Palermo, Italy	205,712
80	1891	West Ham, England	204,902
81	1890	Milwaukee, United States	204,468
82	1890	Magdeburg, Germany	202,235
83	1891	Lille, France	201,211
84	1882	Alexandria, Egypt	200,755
85	1885	Santiago, Chile	200,000
86	1891	Kingston-on-Hull, England	199,991
87	1888	Havana, Cuba	198,261
88	1891	Salford, England	198,136
89	1888	Riga, Russia	195,668
90	1891	Delhi, India	193,580
91	1888	Kharkoff, Russia	188,469
92	1891	Mandalay, India	187,910
93	1891	Newcastle, England	186,345
94	1891	Singapore, Singapore	184,554
95	1890	Prague, Hungary	184,109
96	1891	Kieff, Russia	183,640
97	1891	Cawnpore, India	183,210
98	1891	Newark, United States	181,830
99	1891	Toronto, Canada	181,220
100	1891	Rangoon, India	181,210

In view of the preponderating influence exercised by great cities upon the progress and welfare of the world, it is extremely interesting to note that more than one-half of the cities herein named are either populated by English-speaking races or are under their control. Of these fifty-two cities, two are in Australia, two in Canada, one in China, two in Egypt, thirteen in England, ten in India, two in Ireland, two in Scotland, one in Singapore and seventeen in the United States.

It is not the purpose of this sketch to investigate the causes which particularly favor the enormous aggregations in modern cities, for such causes must be complex, local, and numerous. It is evident, however, at a glance, that the elements of easy transportation and a moderately rigorous climate are the most frequent concomitants, if they are not the predominating causes. As some one not very wisely remarked, "it is fortunate that great rivers run by so many great cities," and in this list but few cities are found which have not facilities for water transportation. By far the greater number of large cities are situated climatically in an average temperature between 45° and 55°. In the parts of Europe and America where these annual temperatures prevail there is one city of 100,000 inhabitants to about every 2,000,000 of population. In Russia there is only one such city to over 9,000,000, and in India one to over 10,000,000 souls.

With but few exceptions the populous cities of the world are the product of the age, as is illustrated by the fact that at the beginning of this century the United States had no city of one hundred thousand inhabitants, while now it has twenty-eight; England had one only, now it has twenty-four.

OUR YOUNGEST VOLCANO

BY

J. S. DILLER

(*Presented before the Society April 28, 1893*)

Our youngest volcano is in Alaska. There was an eruption at Bogoslov in October, 1883, and at other points since then, and there can be no doubt whatever concerning the existence of active volcanoes in Alaska. In our own country, exclusive of Alaska, there may be some doubt whether living volcanoes exist.

It is well known to all, no doubt, that the greatest volcanic region in the world lies in the northwestern part of our own country, occupying a large tract in Idaho, Washington, Oregon and California. There were many active volcanoes there during the middle and latter portions of the Tertiary period, and there is still a considerable number of them which can hardly be called extinct.

Frequent reports of volcanic eruption may be seen in western newspapers, but the large majority of them are of doubtful authenticity. There is considerable evidence, however, that in 1842–'43 mount Baker and mount Saint Helens, in Washington, discharged large quantities of "ashes" with which the adjacent country was covered as with a light fall of snow. Professor Davidson, of the United States Coast and Geodetic Survey, and Mr J. S. Hittel report eruptions of mount Baker in 1854, 1858 and 1870. These reports are based on observations made at long range, and so far as I know have not been corroborated by actual ascent of the mountain.

Dr Harkness, of San Francisco, reported to the California Academy of Sciences a volcanic eruption in Plumas county of that state, at a point about ten miles northeast of Lassen peak. He found the trees near the lava were scorched as if by the heat of the lava at the time of the eruption. He visited the locality,

and from data he gathered there, with historical evidence from natives and early settlers in the Sacramento valley, he concluded that the eruption occurred in January, 1850.

In 1885 Captain (now Major) Dutton and I visited the region and, approaching it from the same side as Dr Harkness did, saw no reason whatever to doubt his conclusions. A few years previous Major Dutton had studied the active volcanoes of the Sandwich islands, and he was deeply impressed with the newness in the appearance of the lava field and cinder cone northeast of Lassen peak.

Later in the same season I revisited the volcano alone for the purpose of studying the phenomena more thoroughly, and found good reason for believing that it is very much older than was at first supposed.

Pine trees grow from terminal buds in joints at the rate of one joint each year; so it was thought that if we could find a living tree that was well scorched we could climb up and count the number of joints above the scorching and could thus discover the number of years since the eruption.

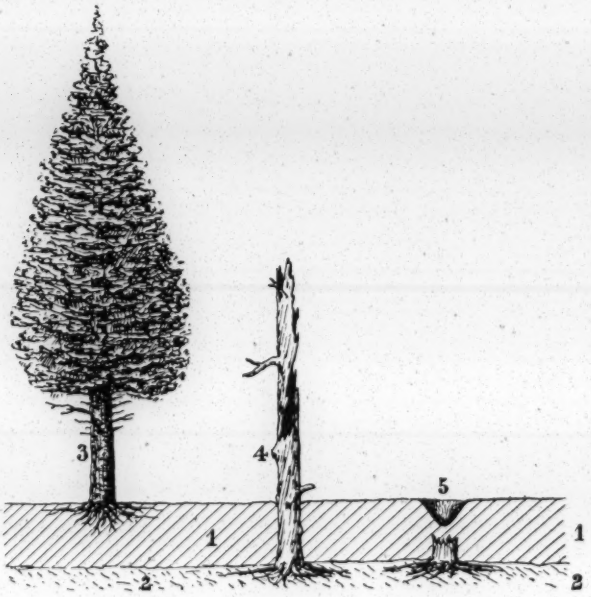
We started out around the lava field to find a suitable tree, but to our great surprise on the further side of the lava field the scorched sides of the trees were away from the lava, so that it was evident that the scorching was not produced by the lava. A little further examination convinced us that a forest fire had swept through that region from the north and scorched all the trees more or less on that side.

We returned to the cinder cone and, finding large pine trees growing close to the cone, it was doubted whether the trees could have survived so close to the volcano. The question arose as to the thickness of the layer of volcanic sand near the cone where the trees were growing; and with soup-plates for shovels (we had no better in camp) we dug down to find the bottom, but the loose sand caved in and we could not penetrate it. A quarter of a mile away from the base of the cinder cone another attempt was made, and at that distance the layer of volcanic sand was found to be seven feet thick. Of course, it was evident at once that no living trees in the neighborhood could have survived such a shower of hot "ashes." The large living trees must have grown up entirely since the eruption.

Near the cinder cone there are some dead trees which have been partially burned. Examining these it was found that they had

not grown on the top of the layer of volcanic sand like the living trees, but that they extended down through this layer to the original soil beneath. The relation of the old and new forest trees, as well as that of the stumps of the older forest, is shown in the accompanying sketch (figure 3).*

It is evident that the tree from the original soil beneath is older than the eruption, and that since the tree was either dead

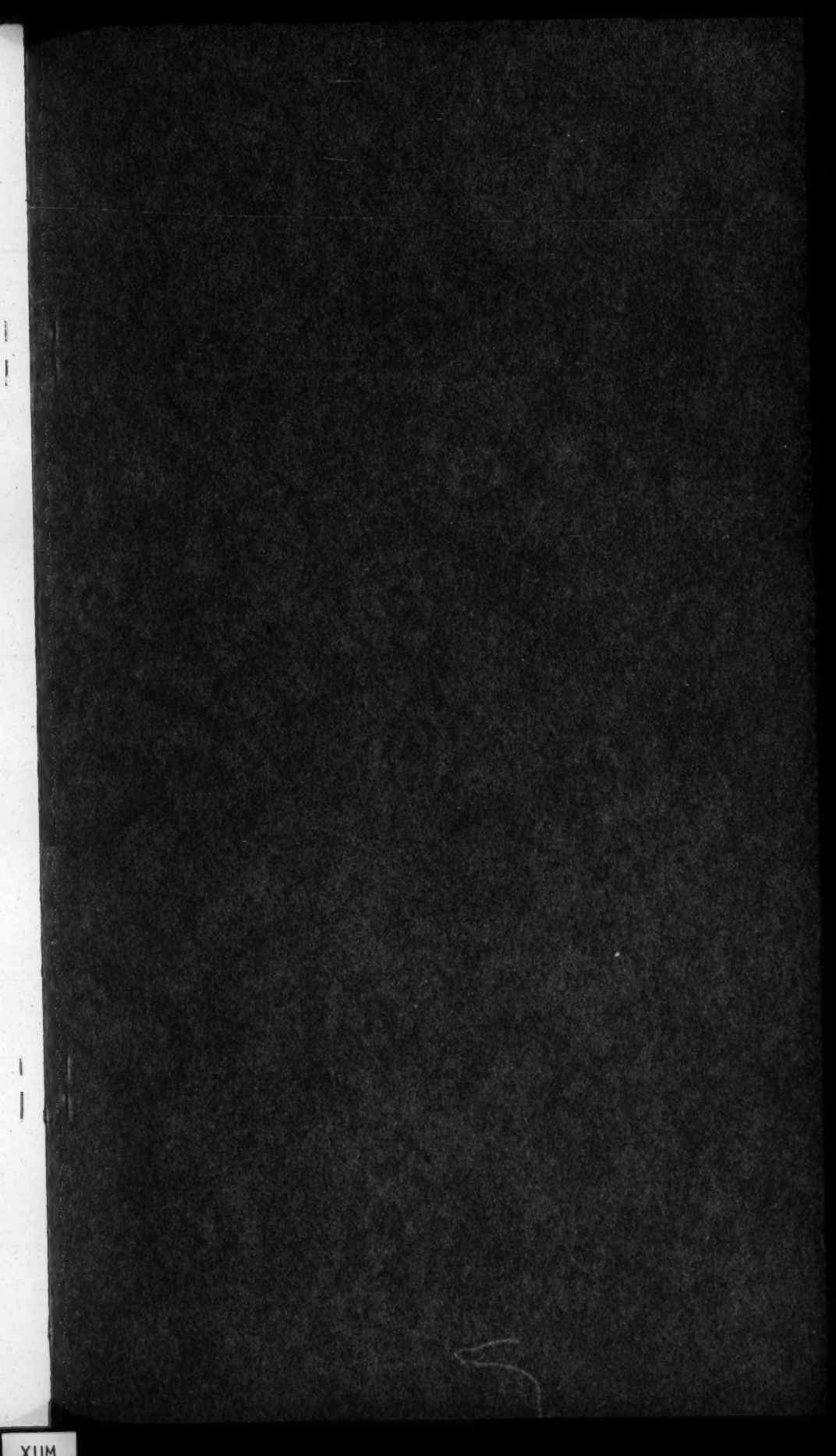


1 Volcanic Ashes Lapilli &c
2 Original soil.
3 Present forest tree
4 Tree of former forest killed by shower of Volcanic Ashes Sand &c.
5 Pit formed by the decay of old forest tree.

FIGURE 3.—*Relations of older and younger Forests to volcanic Sand.*

or killed at that time and has not completely decayed, that the eruption cannot have occurred many centuries ago. Of the time that has since elapsed we have some measure in the age of the living trees. In the same region the timber is cut for lumber, and by counting the number of rings of growth it was found that the

*Reproduced from Bulletin 79, U. S. Geol. Survey, 1891, p. 20.

largest trees near the cinder cone are not less than 200 years old, so that the eruption at the cinder cone must have occurred a little more than 200 years ago.

On the whole, it would seem probable, therefore, that our youngest volcano south of Alaska is not the cinder cone ten miles northeast of Lassen peak as once supposed, but is most likely to prove to be mount Baker, in Washington.